The Efficacy of Midwater Artificial Structures for Attracting Pelagic Sport Fish[1]

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ABSTRACT

Field experiments were conducted in the northeastern Gulf of Mexico off Panama City, Florida to evaluate the feasibility of using man-made midwater structures for attracting pelagic game fish to improve sportfishing catch rates. Significantly greater catches of little tunny (*Euthynnus alletteratus*), king mackerel (*Scomberomorus cavalla*), and dolphin (*Coryphaena hippurus*) were made around experimental structure sites than in adjacent control areas when equal experimental fishing effort was used.

Multiple structures attracted larger numbers of coastal pelagic bait fish and produced larger catches of pelagic game fish than single-structure units. The distance offshore or water depth of structure locations affected both the species of fish attracted and the number of fish caught.

Charter fleet vessels fished around one of the experimental structures for several hours and reported total numbers of pelagic game fish caught and catch rates at least double those in "other areas" for that day.

INTRODUCTION

Certain species of pelagic fishes are frequently found in association with natural and man-made objects in the sea. This knowledge is used routinely by both sport and commercial fishermen. Many marine sport fishermen often make their best catches around marker buoys, old logs, drifting seaweed, and other objects. Commercial fisheries based on associations of pelagic fishes with objects in the sea have been reviewed by von Brandt (1960) and Hunter and Mitchell (1967, 1968). Studies by Hunter and Mitchell (1968) and Klima and Wickham (1971) indicated 3-dimensional objects positioned in midwater were effective for attracting some species of pelagic fish. The potential application of midwater artificial structures to improve pelagic sport fish catches was suggested by Wickham and Russell[4] from observations obtained while they evaluated the use of midwater artificial structures for attracting coastal pelagic bait fishes (i.e., sardines, herring, small jack).

The purpose of our study was primarily to evaluate the feasibility of using midwater artificial (man-made) structures for improving sport catches of pelagic game fish. The field experiments were conducted in two phases each of 5 days' duration. The first phase was designed to provide data on the species available to sport fishing gear at artificial structures and to evaluate catch rates around single structures, multiple structures, and in control areas. The second phase was a preliminary evaluation of the effect of structure distance offshore (water depth) on species composition and catch rates and included a comparison between structures and control areas at each station.

MATERIALS AND METHODS

Our studies were conducted in the Gulf of Mexico off Panama City, Florida, August 1971. The geographical location and spacing of structure sites and control areas are illustrated in Figure 1.

The structures were 3-dimensional white objects deployed approximately 5 meters (16 feet) beneath the surface. Each had a rigid frame in one plane and a collapsible rope bridle frame in the other planes. The frames were covered with white vinyl cloth. This

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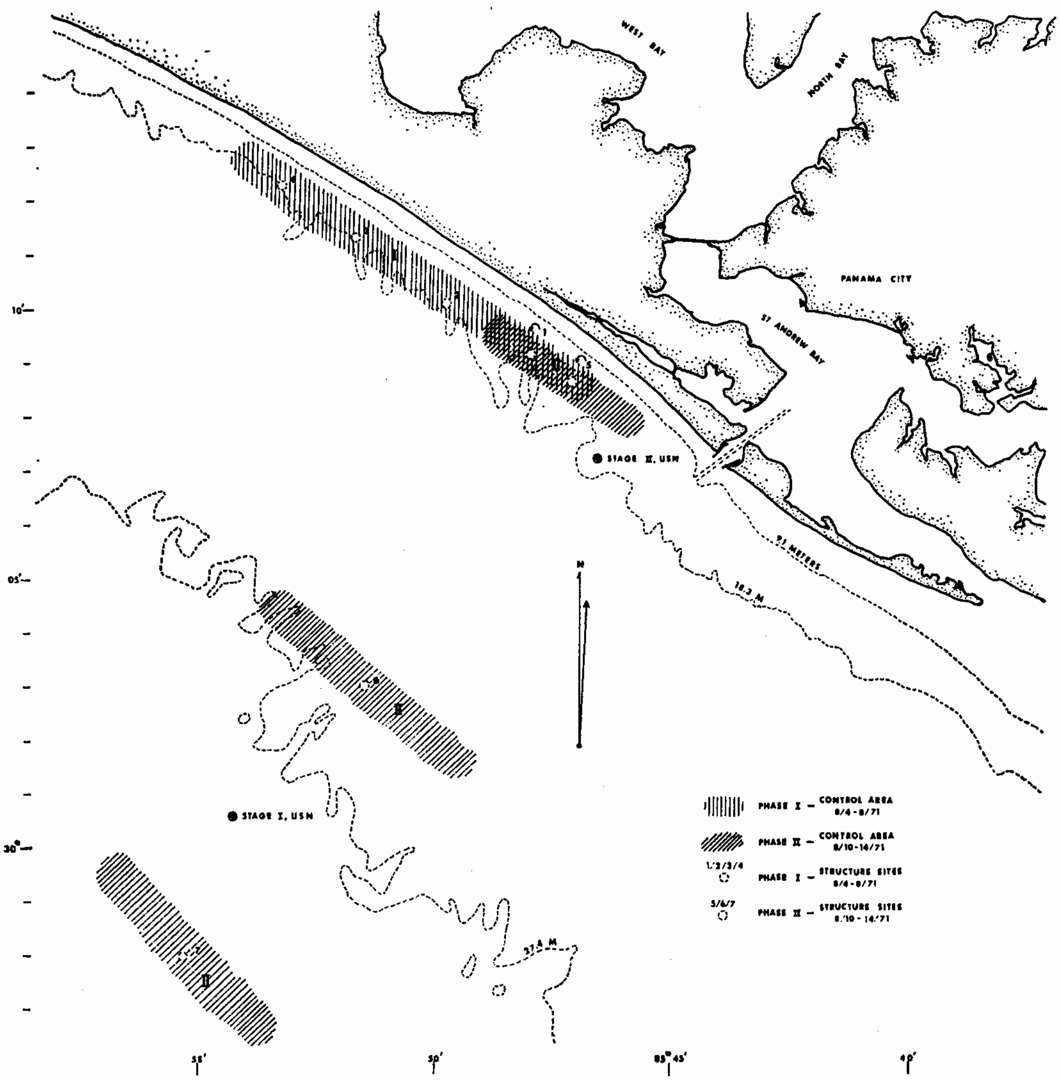

FIGURE 1.—Map of the study area off Panama City, Florida illustrating locations of experimental structures and control areas.

design reduced weight and facilitated handling and storage by allowing the units to be collapsed aboard ship, while permitting expansion to create 3-dimensional structures when deployed at sea. Two types of structures, single and multiple, were used during this study. Single structures were pyramidal with 1.2-meter (4-foot) sides and a rigid, negatively buoyant triangular base frame (Fig. 2). Units used in the multiple structure were conical with a 1.2-meter (4-foot) diameter, semi-rigid buoyant base frame and a height of 1.5 meters (5 feet). Multiple structures consisted of five buoyant inverted cones spaced at 20-meter (66-foot) intervals and tethered 5 meters (16 feet) beneath the surface by weighted lines attached to an anchored groundline (Fig. 3). The spacing was selected on the basis of the distance limits of underwater human vision in the study area. The distance was approximately 10 meters (33 feet). Thus, assuming that fish had similar visual capabilities, at

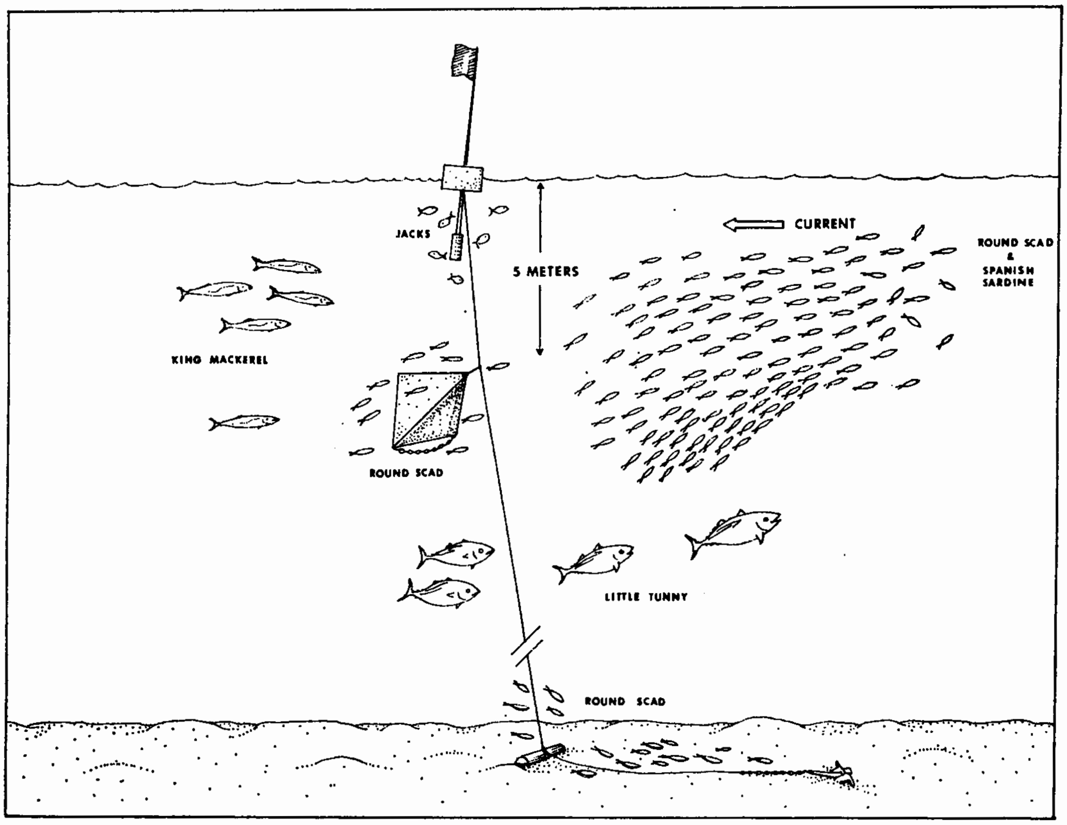

FIGURE 2.—An illustration of the mooring arrangement used for deploying single structures. The characteristic positions of fish around the structure are shown schematically.

20-meter (66-foot) intervals any fish swimming through the array of inverted cones would pass within visual range of the structure. Mooring and handling methods necessitated the configuration differences between units used for single and multiple structures. Observations reported by Wickham and Russell (MS) indicated these minor differences would not significantly affect the attraction stimulus strength of the structure units.

The NMFS R/V RACHEL CARSON, a 13-meter (44-foot) sport fishing cruiser, was used for collecting comparative fishing data. Sampling gear consisted of four monofilament handlines fished at a trolling speed of 6 to 8 knots. Two lines were fished at the surface using artificial lures (No. 2 spoons or a spoon-feather jig combination). The other two lines were fished below the surface using hooks baited with round scad (*Decapterus punctatus*) which were changed regularly at 10-minute intervals.

Our experimental design required equal fishing effort at all structure sites and control areas. Structure sites were defined as the area within an approximately 100-meter (330-foot) radius of a structure. Structure site dimensions were selected to include bait schools attracted to the structures and to provide maneuvering room for the sampling vessel. Fishing procedures at the structure sites involved repeatedly trolling past the structures for predetermined sampling periods. Control areas were adjacent to, but beyond 100 meters from a structure site. In the control areas, normal sport fishing procedures were followed with trolling effort being spent around tidal rips, bait fish schools, and drifting weed patches for a time equal to that spent around structure sites. Daily sampling

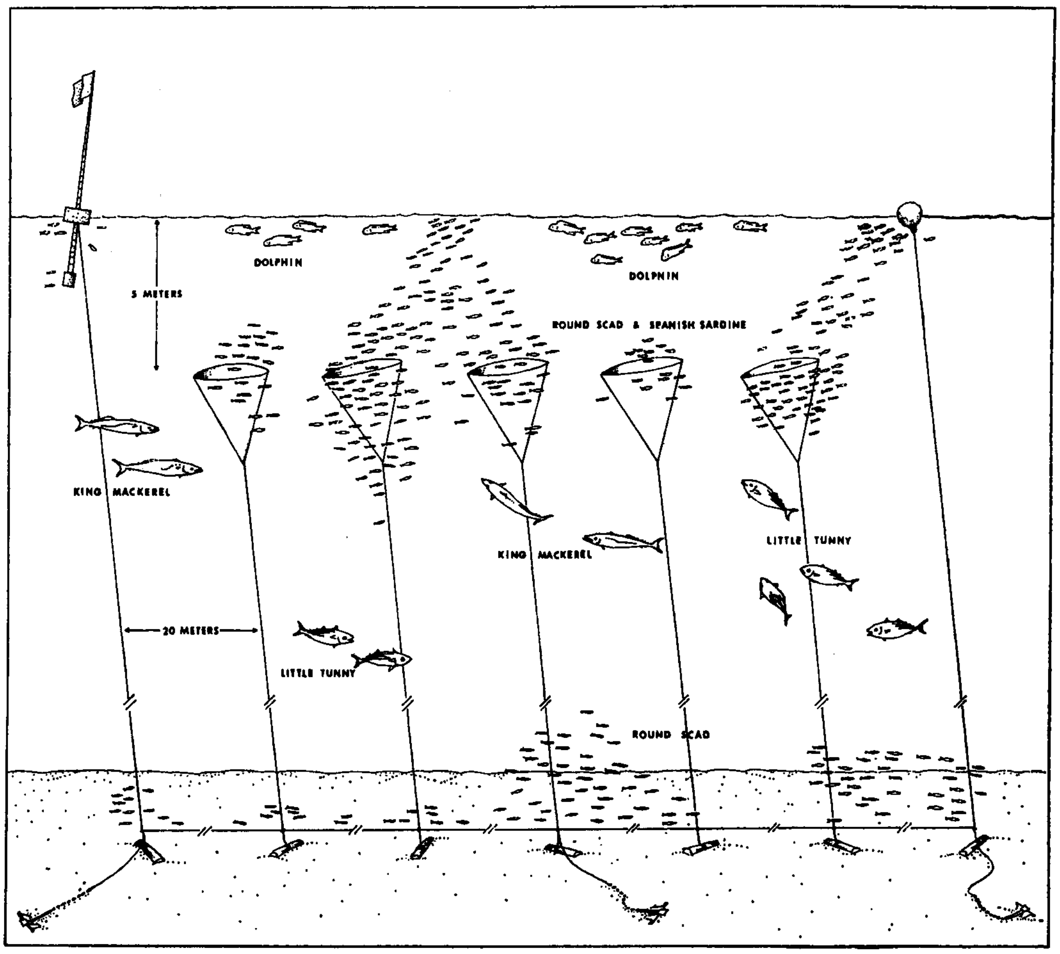

FIGURE 3.—An illustration of the mooring arrangement used for deploying multiple structures. The characteristic positions of fish around the structures are shown schematically.

periods at each structure and control area were separated into three 20-minute periods during Phase I and two 30-minute periods during Phase II. The time of day for each sampling period was changed daily.

Data on catch, strikes, and effort were recorded. The catch was recorded by species and by number when fish were landed. Length, weight, sex, stomach contents, and type of lure were obtained for all catches. Strikes were defined as hits on the lures hard enough to free the fishing line from a clothespin. Fishing effort was recorded only for time the lures were in the water.

An analysis of variance was used to test for significant differences in catch and strike data among structures, controls and station depths. A simple least significant difference (LSD) was used for analyzing comparisons among treatments when an analysis of variance was significant since the number of treatments were small (i.e., three treatments). Visual observations by SCUBA divers and photographic records were also made at selected structures.

Fishing effort and catch composition data from 11 vessels in the Panama City, Florida charter boat fleet were collected daily during our study by port samplers from the NMFS, Panama City Laboratory. The charter fleet operated without experimental constraints searching out and remaining with the fish as long as they continued striking. These data provided an indication of fishing success in the general study area.

RESULTS

Structures Versus Control Areas

A statistical analysis of our total catch results (Table 1) during this study indicated that a significantly larger number of sport fish ($F = 13.69 > F_{.99\,(1,9)} = 10.6$) were caught around the structure sites than in the control areas. During the first phase of our study, 24 fish were caught at the single and multiple structures, whereas only 5 fish were caught in control areas (Table 1). The combined catch rate for both single and multiple structures was 1.20 fish per hour, while the control area catch rate was only 0.25 fish per hour. The difference in catch rates between structures and controls was even more dramatic during our second phase when only multiple array structures were used. During Phase II, the catch around structures was 105 fish compared to 19 fish from the control areas (Table 1). The catch rate around structures was 7.00 fish per hour; in the control area the catch was 1.27 fish per hour. The difference between structures and control areas was even greater when strike data were examined.

Single Versus Multiple Structures

Single and multiple structures were both deployed during the first phase of our study. Catch results were compared to determine whether there would be any difference in the number of pelagic fish attracted to the two types of structures. Our surface observations indicated larger schools of bait fish were attracted to the multiple structures.

The sport fish catch around all structures used during Phase I was significantly greater ($F = 5.41 > F_{.95\,(2,8)} = 4.46$) than catches from control areas (Fig. 4). Further statistical analysis of these data revealed that catches from multiple structures were greater than those from either single structures ($LSD = 0.46 > t_{.85,8} = 0.45$) or control areas ($LSD = 0.55 > t_{.85,8} = 0.45$). The single structures also provided larger catches than control

TABLE 1.—*Summary of catches, strikes*[a] *and effort for experimental trolling around midwater artificial structures and control areas during Phases I and II*

Date 1971	Sampling area	Hours fished	Little tunny *E. alletteratus* Number caught	Little tunny Catch per hour	King mackerel *S. cavalla* Number caught	King mackerel Catch per hour	Spanish mackerel *S. maculatus* Number caught	Spanish mackerel Catch per hour	Dolphin *C. hippurus* Number caught	Dolphin Catch per hour	All species combined Number caught	All species combined Catch per hour	All species combined Number of strikes	All species combined Strikes per hour
4–8 August	All stations (18 meters)													
Phase I	Control areas	20	5	0.25	0	0	0	0	0	0	5	0.25	12	0.60
	Single structures	10	4	0.40	1	0.10	0	0	0	0	5	0.50	12	1.20
	Multiple structures	10	6	0.60	12	1.20	0	0	1	0.10	19	1.90	38	3.80
10–14 August	Station I (18 meters)													
Phase II	Control area	5	4	0.80	2	0.40	1	0.20	0	0	7	1.40	9	1.80
	Multiple structure	5	8	1.60	6	1.20	1	0.20	0	0	15	3.00	63	12.60
	Station II (26 meters)													
	Control area	5	1	0.20	0	0	0	0	4	0.80	5	1.00	9	1.80
	Multiple structure	5	3	0.60	1	0.20	0	0	51	10.20	55	11.00	137	27.40
	Station III (32 meters)													
	Control area	5	6	1.20	1	0.20	0	0	0	0	7	1.40	9	1.80
	Multiple structure	5	4	0.80	0	0	0	0	31	6.20	35	7.00	89	17.80

[a] Includes strikes which resulted in catches.

TABLE 2.—*Summary of length, weight, and sex of species caught during Phases I and II*

Species	Number caught	Fork length in cm		Weight in kg		Sex composition		
		Range	$\bar{X}$	Range	$\bar{X}$	Male	Female	Immature
Little tunny (*E. alletteratus*)	41	28.5–72.0	48.64	0.2–5.9	1.67	16	20	5
King mackerel (*S. cavalla*)	23	58.0–88.5	65.43	1.4–6.4	2.32	0	23	0
Spanish mackerel (*S. maculatus*)	2	35, 37.5	36.25	0.2, 0.5	0.34	1	1	0
Dolphin (*C. hippurus*)	87	22.5–46.5	35.52	0.1–0.5	0.25	40	46	1

areas, but the difference was not statistically significant (LSD $= 0.09 < t_{.75, 8} = 0.31$).

Analysis of species composition of the catch from control areas, single structures, and multiple structure arrays during the first phase showed that little tunny were captured in larger numbers around structures than in control areas (Table 1). All of the king mackerel were caught around structures, with 12 of the 13 fish being taken from multiple structures. The single dolphin captured during Phase I was taken at a multiple structure.

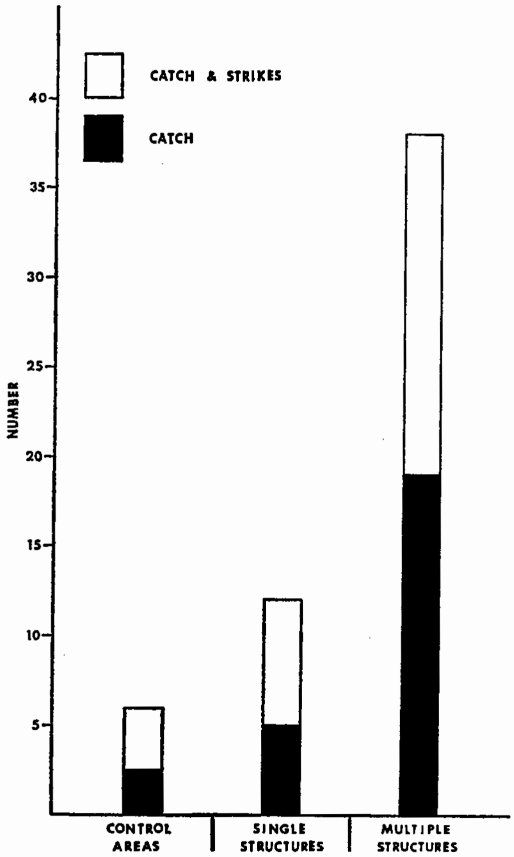

FIGURE 4.—Catches and strikes for control areas, single structures and multiple structures during Phase I. Control area data were adjusted for 10 hours' effort to permit direct comparison with structure data.

One multiple structure was placed parallel with and another perpendicular to the current direction during Phase I. Catch data indicated the two positions were equally effective for attracting bait fish schools and pelagic game fish.

Our decision to use only multiple structure arrays during the second phase of this study was based on the results of the first phase.

Structure Distance Offshore (Water Depth)

During the second phase of our study we established a multiple structure and control area in three selected water depths. Catch data from these stations provided preliminary information on the effects of distance offshore on catch rates and catch species composition. Area I was located in 18 meters (60 feet), II in 26 meters (85 feet) and III in 32 meters (105 feet) of water, resulting in an offshore spacing of approximately 9.6 kilometers (6 miles) between sampling areas (Fig. 1).

Structures produced larger catches than control areas at all depths (Fig. 5). Statistical analyses of the comparative catch data from structures and control areas produced values of ($F = 3.72 > F_{.75\,(1,4)} = 1.81$), ($F = 2.8 > F_{.75\,(1,4)} = 1.81$), and ($F = 4.8 > F_{.90\,(1,4)} = 4.54$) for areas I, II, and III, respectively. Analyses of combined catch and strike data produced F values significant at .90 or higher for structures in all sampling areas.

Statistical analyses of only Phase II structure catch data for all species combined by depth indicated that structure placement offshore had a significant effect ($F = 4.79 > F_{.95\,(2,8)} = 4.46$) on the number of fish caught. More fish were caught at Structure II in 26 meters than at either Structure I (LSD $= 3.1 > t_{.85,8} = 2.52$) or Structure III (LSD $= 2.0 > t_{.75,8} = 1.60$). No statistical difference was found between the number of fish caught at Structures I and III (LSD $= 1.1 < t_{.75,8} = 1.60$).

Differences were observed in the species composition of the catches among structures by depth (Table 1). Little tunny were caught, as during Phase I, in larger numbers at structures than control areas. King mackerel were taken most frequently around Structure I in 18 meters (60 feet) of water, although individuals were also caught at structures and control areas in other depths. Dolphin were caught most frequently around the structures; a few were captured around floating patches of *Sargassum* in control areas. The largest numbers of dolphin were caught offshore at Structures II and III. The Spanish mackerel were caught at the structure and control area I in 18 meters (60 feet). These results may be indicative of differences in relative abundance of game fish at the various distances offshore; however, vertification will require further study.

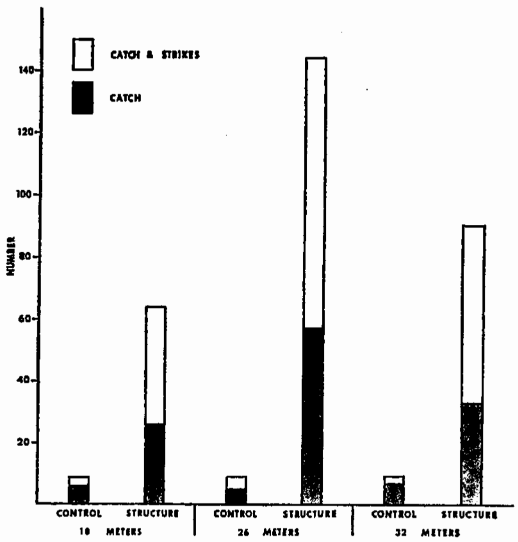

FIGURE 5.—Catches and strikes for control areas and multiple structures by station depth during Phase II.

Observations

Our observations of bait fish schools and pelagic game fish, made while we were SCUBA diving at the experimental structure sites, were similar to those reported by Klima and Wickham (1971) and Wickham and Russell (MS). These observations were useful in supplementing our catch and strike data to provide estimates of fish abundance.

Diver observations revealed the presence of fish around a structure when none were captured or when they were present in greater numbers than indicated by the trolling catches. Diver and surface visual observations also revealed the presence of species not represented in our catches. The most abundant bait fish present at the structures were round scad (*Decapterus punctatus*) and Spanish sardine (*Sardinella anchovia*). Divers also observed schools of blue runner (*Caranx crysos*), bar jack (*Caranx ruber*), and occasionally chub mackerel (*Scomber japonicus*).

Pelagic sport fishes captured at the midwater structures during this study consisted of little tunny (*Euthynnus alletteratus*) king mackerel (*Scomberomorus cavalla*), and dolphin (*Coryphaena hippurus*). Two 36-cm (14-inch) Spanish mackerel (*Scomberomorus maculatus*) were also caught. Sightings were made of several cobia (*Rachycentron canadum*), great barracuda (*Sphyraena barracuda*), and a hammerhead shark (*Sphyrna* sp.) at the structures, but none were caught. On one occasion we also observed a sailfish (*Istiophorus platypterus*) at the surface feeding on the bait fish school around a structure in 18 meters (60 feet) of water.

The recruitment of bait fish schools (usually a mixture of round scad and Spanish sardine) to our structures was rapid. Schools were present the morning following structure placement. This rapid recruitment of bait fish to artificial structures was described by Klima and Wickham (1971) and Wickham and Russell (MS). Pelagic sport fish apparently accumulated almost as quickly around the structure sites as did the bait fish. During our first sampling period, the daily total of catches and strikes increased slightly over the first several days. This increase was apparently indicative of improved fishing in the study area, since catches at both our structure and control areas showed a similar relative in-

TABLE 3.—*Catch-per-hour by species for the R/V RACHEL CARSON and charter fleet vessels in non-structure areas during Phase II (9–15 August 1971)*

Species	Experimental control areas (15 hours' fishing)	Charter fleet "other areas" (159 hours' fishing)
Little tunny (*E. alletteratus*)	0.73	0.31
King mackerel (*S. cavalla*)	0.20	0.62
Spanish mackerel (*S. maculatus*)	0.07	0.006
Dolphin (*C. hippurus*)	0.27	0.59

crease. The largest catches during the second phase of our study were made on the first day following structure placement. We observed no significant increase in catches or strikes with increasing structure soak time for either study period.

Fishing was very poor in the northeastern Gulf of Mexico during Phase I (2–8 August) with many boats in the charter fleet making repeated trolling trips but failing to produce any fish.

Fishing improved during Phase II (9–15 August). During Phase II the catch per unit effort for the charter fleet was more than twice the value of our control area catch for king mackerel and dolphin but less than half for little tunny and Spanish mackerel (Table 3). Our higher catch rates for the little tunny and Spanish mackerel can be attributed to the charter fleet's preference for fishing with bait (round scad) trolled below the surface, since over 70% of our little tunny and both of our Spanish mackerel were caught with surface spoons. Our fishing effectiveness was, as expected, relatively low in comparison with that of the charter fleet for the preferred sport fish species. This lower fishing effectiveness can be attributed to our lack of fishing skill, less efficient gear (handlines) and restrictions on our fishing activities in time and area by experimental design.

Charter Fleet Catches at Artificial Structures

During both Phases I and II of this study, little or no uncontrolled fishing effort was expended at the structures. Structure I in 18 meters (60 feet) of water, was discovered and fished by several boats from the charter fleet after we completed our sampling on the final day of Phase II. Radio contact was made with several of the charter boats fishing Structure I which agreed to record their fishing time and catch at the structure. On 14 August 1971 the charter boats reported catching more fish at our Structure I than in the "other areas" fished that day, and their catch per hour at the structure was at least double that in "other areas" for little tunny, king mackerel, and dolphin (Table 4). The charter boats stopped fishing at 1500 hours at which time we recovered the structure, completing this study. These data are probably conservative since catch data could not be obtained from all the sport boats fishing the structure. Several were observed to have made good catches of king mackerel. Our two 30-minute sample fishing periods at Structure I earlier that day produced a total of two little tunny, three king mackerel, and eight dolphin.

TABLE 4.—*Summary of the number of fish caught and catch per hour by species for five charter fleet vessels fishing at experimental structure I and "other areas" (14 August 1971)*

	Structure I (10 fathoms) 13 hours fished		"Other areas" 23 hours fished	
Species	Number caught	Catch per hour	Number caught	Catch per hour
Little tunny (*E. alletteratus*)	9	0.69	7	0.30
King mackerel (*S. cavalla*)	38	2.92	24	1.04
Dolphin (*C. hippurus*)	9	0.69	5	0.22
Great barracuda (*S. barracuda*)	0	0	1	0.04
Total	56	4.30	37	1.60

BEHAVIORAL INTERPRETATIONS

The attraction of pelagic game fish to artificial structures seems to involve species specific behavioral mechanisms. Little tunny and king mackerel were seldom observed or captured at the structures unless bait fish were present. These species apparently were not attracted by the structures *per se*, but rather by the presence of structure-attracted bait fish schools. Some species of pelagic game fish (i.e., dolphin, cobia, great barracuda) do appear to be attracted by the structures, since these species were occasionally observed around structures when bait fish schools were apparently not present.

The responses of bait fish schools around structures to the presence of pelagic predators were observed by Wickham and Russell (MS). They report bait fish were apparently able to utilize the structures for predator avoidance. Mitchell and Hunter (1970) reported a similar observation; prey were more successful in escaping capture by ocean whitefish (*Caulolatilus princeps*) in an aquarium when kelp was present than when it was absent. During SCUBA dives at the structures, we observed that predator attacks on the bait fish schools were seldom successful, although on almost every occasion when a structure was removed from the water, the bait fish school, which was previously undisturbed, would immediately be subject to a frenzied attack by feeding pelagic game fish. These observations support the hypothesis that bait fish are able to use artificial structures for predator avoidance. The effectiveness of predation by pelagic game fish may be reduced by bait fish schools through the introduction of competing visual stimuli (i.e., the structure) which disrupts the predator's visual fix on the prey required for a successful attack. Further objective study will be required to elucidate the behavioral mechanisms and dynamics involved in the attraction of specific species of pelagic game fish to artificial structures.

CONCLUSIONS

The deployment of artificial structures for concentrating pelagic game fish was shown to be an effective method for improving catches by sport fishermen. The simple economical design of the structures and their relative ease of deployment and retrieval make this technique usable by individual weekend sport fishermen as well as fishing clubs and charter fishing fleets. The subsurface deployment of these structures also prevents them from interfering with other boating interests, and if snared by a commercial fisherman's trawl, they would cause little damage to his nets. The use of artificial structures for fish attraction is a passive technique. Its effectiveness is dependent upon factors such as water clarity, which affects the visible range of the structure, and the availability of attractable fish moving through the area where the structures are deployed. Structures function only to concentrate fish already available in an area, thereby reducing the amount of water through which a bait or lure must be towed before being detected by a fish.

The restricted periods imposed on our fishing effort by the experimental design can be assumed to have reduced the total number of fish caught during this study, since on many occasions fishing at structures had to be stopped while good catches were still being made. On the one occasion when charter boats fished around an experimental structure, they reported a catch rate at least double that in "other areas" trolled for little tunny, king mackerel, and dolphin.

Visual observations and experimental catch data revealed the number of bait fish attracted and the catch of pelagic game fish to be greater for multiple structures than for single structures. The use of multiple structures significantly increases the range of underwater visibility, apparently increasing the chance of pelagic bait fish schools and game fish encountering the structures while moving through the area.

The distance offshore (water depth) of structure placement influenced both the species of fish attracted and the number of fish caught. Results from this study suggest that artificial structure-fish attraction techniques might be developed as indicators of the availability of pelagic game fish in selected areas. Routine monitoring could provide data for directing sport fishing effort for specific pelagic species to high density areas. Incorporated into a properly designed program, these structures might also provide a means for obtaining data on the ecology, behavior and abundance for selected species of pelagic game fish.

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